

Semi-Annual Report to the National Aeronautics and Space Administration concerning  
the Astrophysical Data Program entitled:

THE CHROMOSPHERE/SHOCK DILEMMA OF NON-MIRA,  
LATE-TYPE VARIABLE STARS

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Semi-annual Status Report (NAS 5-32863) covering 9/01/94 - 03/31/95.

The Chromosphere/Shock Dilemma of Non-Mira, Late-Type Variable Stars

Donald G. Luttermoser, P.I. (Applied Research Corporation)

**Summary:** This NASA contract covers Luttermoser's, Willson's, & Bowen's ADP research program, which involves a detailed investigation of the atmospheric structure of non-Mira, asymptotic giant branch stars through NLTE radiative transfer modelling. Synthetic spectra resulting from these calculations will be compared with IUE observations of these stars to test the validity of the models.

## 1 Progress in the past 7 months:

The first half year of this program primarily concerned itself with initial set-ups. Luttermoser made a trip to Ames, Iowa the first week of November 1994 to meet with collaborators at Iowa State University. During this meeting, Luttermoser, Willson, and Bowen discussed and formulated an outline of the proposed research. Physical parameters (*i.e.*, mass, radius, luminosity, effective temperature, and pulsational period) were obtained for our stellar sample (*i.e.*,  $\gamma$  Her (M6 III) & R Lyr (M5 III)) through the SIMBAD data base.

All of the IUE spectra required for this work was obtained from the NSSDC (see Table 1). Data reductions for this spectra is currently underway. Ground-based spectra taken over the past few years of stars in our sample also were reduced during this time. This data includes high-dispersion (0.2 Å) spectra in the 3900-4500 Å region.

NLTE radiative transfer calculations of a hydrostatic equilibrium chromosphere plus shock atmosphere have begun. Figure 1 shows the temperature structure of this model. To date, a 5-level H atom and 5-level He atom have been included in the NLTE calculations.

Luttermoser attended the American Astronomical Society meeting #185 in Tucson, Arizona in January 1995. The group presented a poster that included the reduced data that will be used for the comparison to the synthetic spectra generated from the models (Luttermoser 1995).

## 2 Activities planned for the remainder of Year 1:

An AlphaStation 200 running OSF/1 was purchased through Iowa State University to carry out the NLTE radiative transfer calculations. Luttermoser has just taken possession of this machine as of 21 April 1995. Note that the NLTE calculations mentioned earlier were performed on an older VAXstation 3100. Once our NLTE radiative transfer code PANDORA is set up to run on this machine, the convergence of these calculations will increase by a factor of 50 in CPU time.

Luttermoser has completely used the 3.5 months of salary allocated for the first year. **However, he continues this research on his own time.** The IUE data reduction will continue during this time. Also the NLTE model calculations will continue. Bowen will initiate the hydrodynamic calculations of a model representative of this star during this time.

Finally, a paper discussing the NLTE hydrogen calculations of these shocked atmospheres will be submitted to the *Astrophysical Journal* near the end of Year 1.

Table 1: IUE HI-DISP Spectra Obtained from the NSSDC

Image Number	Star	Exposure Time	Date
LWP 06575	g Her	15 min	4 Aug 1985
LWP 06576	g Her	360 min	4 Aug 1985
LWP 09596	R Lyr	385 min	28 Nov 1986
LWP 11020	R Lyr	20 min	15 Jun 1987
LWP 13442	g Her	40 min	16 Jun 1988
LWP 13443	g Her	880 min	16 Jun 1988
LWP 19097	R Lyr	20 min	31 Oct 1990
LWP 19098	R Lyr	100 min	31 Oct 1990
LWP 25278	R Lyr	20 min	6 Apr 1993
LWP 25279	R Lyr	60 min	6 Apr 1993

### 3. Recent papers and abstracts concerning this research:

Luttermoser, D.G. 1995, *45.13 Fluorescent Clues to the Atmospheric Structure of AGB Stars*, in Bulletin of the Amer. Astro. Soc., 26, 1381

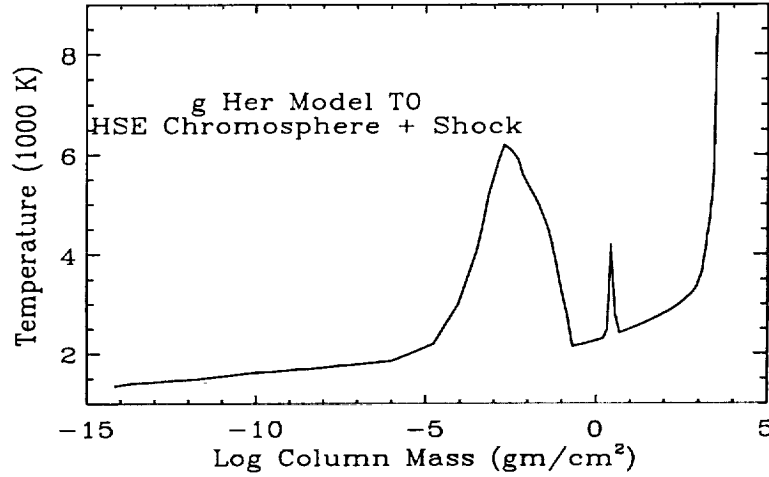


Figure 1: Temperature structure of the HSE chromosphere + shock atmosphere representative of g Her.